
A New Zygomorphic-Flowered *Rinorea* (Violaceae) from the Neotropics

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ABSTRACT. A distinctive new species from the Neotropics, *Rinorea zygomorpha* H. E. Ballard & Wahlert (Violaceae), is described and illustrated. It has several character states unique to Neotropical *Rinorea* Aublet, including a strongly zygomorphic corolla and single-seeded capsule, which distinguish it from other New World species. The new species is also aberrant in several respects in the family, with bifid dorsal connective appendages, stipitate ovary and fruit, and lateral attachment on the laterally compressed seed. A key is presented to separate this new species from other Neotropical members of *Rinorea*. An assessment of IUCN status using Arc-View GIS software with georeferenced localities places the new species in the Least Concern category.

Key words: IUCN Red List, Neotropics, *Rinorea*, Violaceae.

Rinorea Aublet (Violaceae) is a pantropical genus of woody shrubs and small trees with an estimated 155 to 210 species (Ballard, unpublished data). The 48 species of Neotropical *Rinorea* are generally well known, owing to a monograph of the genus by Hekking (1988). *Rinorea* can be a common understory element in lowland tropical rainforests and semi-deciduous forests, yet the diversity and distribution of species are not well understood, particularly for African and Southeast Asian species. No infrageneric classification has been proposed for the entire genus, and phylogenetic relationships among the world's *Rinorea* species are not yet known.

Until now, Neotropical *Rinorea* have been described generally as having actinomorphic corollas (e.g., in floras and diagnostic keys). However, a carefully dissected flower often reveals the tendency toward zygomorphy in the calyx and the corolla. In most cases, three sets of sepals and petals can be identified: one anterior and two pairs each of lateral and posterior sepals and petals. Some species also show zygomorphic symmetry in the ornamentation and insertion of the staminal tube and in the orientation of the style (Hekking, 1988; Wahlert & Ballard, pers. obs.). In Hekking's (1988) careful revision of Neotropical *Rinorea*, it is curious that he did not address the trend toward zygomorphic flowers in some species. Study of floral dissections of Neotropical

Rinorea shows some species to have a subequal calyx and corolla, while others tend toward weakly zygomorphic flowers (Wahlert & Ballard, unpublished data). The strongly zygomorphic corolla of the new species described here makes it instantly recognizable and distinct from all other Neotropical *Rinorea*.

Examination of herbarium material at the Ecuadorian Museum of Natural Sciences (QCNE) revealed specimens with strikingly zygomorphic corollas and zygomorphic, one-seeded capsules that had been misidentified as *Rinorea apiculata* Hekking or *R. guianensis* Aublet. The aberrant specimens superficially resembled *R. guianensis* in their phyllotaxy, gross leaf morphology, and thyrsoid inflorescences, but were immediately distinct from it upon scrutiny of the flowers and fruits. Subsequent examination of other collections uncovered many additional misidentified specimens of a fairly widely distributed Neotropical species with strongly zygomorphic corollas and unusual fruits. The new species is now represented by collections at two separate sites in east-central Panama and many specimens from approximately 20 more sites in eastern Ecuador and adjacent Peru (Fig. 1).

Intensive study of accumulated material from AAU, MO, U, and WIS has revealed a suite of characters not seen in other Neotropical *Rinorea* species or, in some cases, other genera of the Violaceae. Features not documented previously in Neotropical *Rinorea* include the strongly zygomorphic corolla, single seed per capsule, and zygomorphic capsule symmetry (but with straight sutures). Other traits that are novel in the family are the bifid apices of the dorsal connective scales, the maturing ovary enlarging apically as a "cap" that differs in color and texture from the ovary base, the strongly indented dehiscence sutures on the ovary "cap" and mature fruit, the stipitate base of the ovary persisting into fruit, and the lateral attachment of the laterally compressed asymmetrical seed. This assemblage of novel character states (Fig. 2) initially led us to conclude that the misidentified taxon was probably a new genus. However, evidence from DNA sequences of the *trnL* intron and *trnL-F* spacer strongly support placement of the new species within *Rinorea* and more specifically with Neotropical taxa (see below).

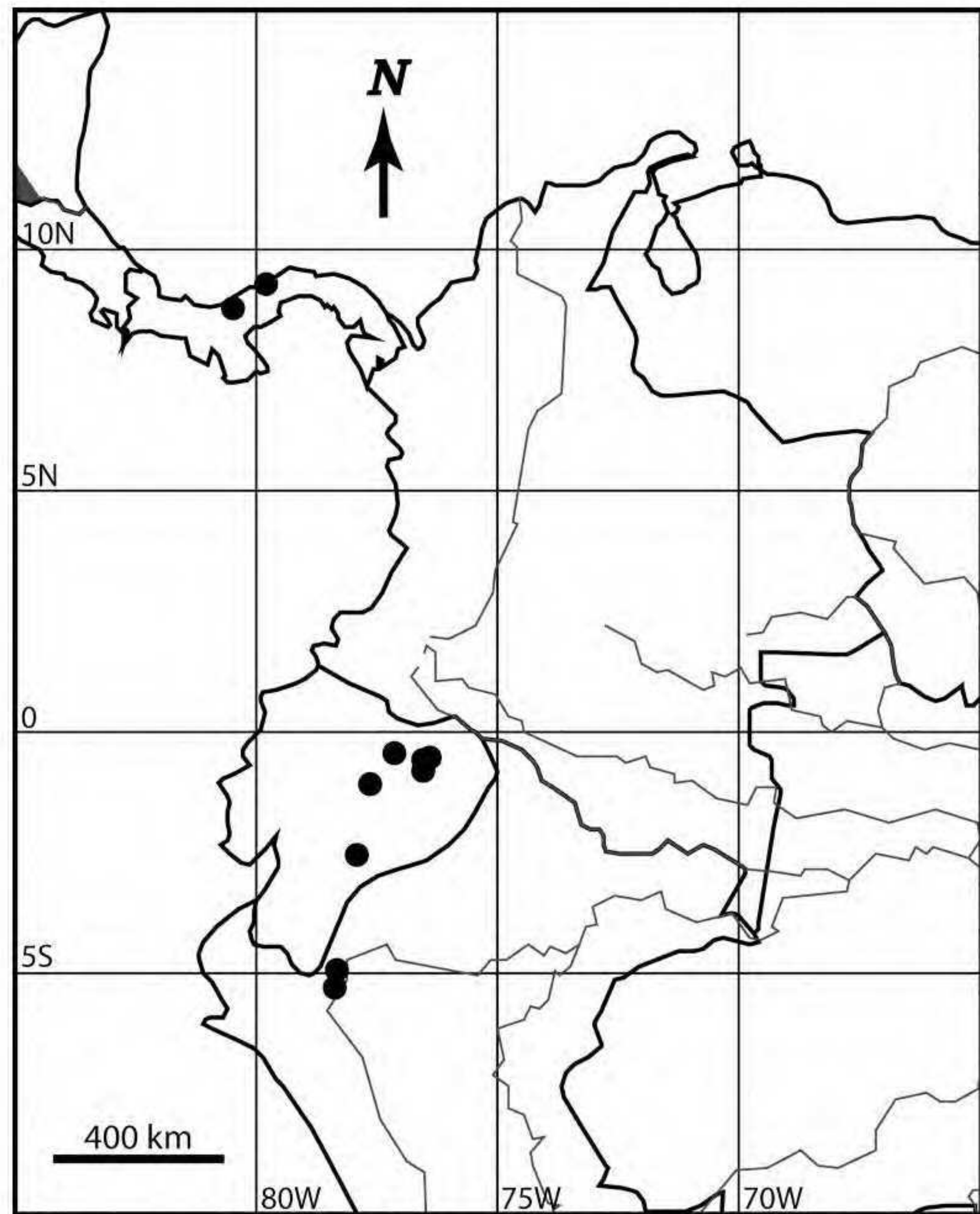


Figure 1. Geographic distribution of *Rinorea zygomorpha* H. E. Ballard & Wahlert in Latin America.

The diagnostic key presented below, adapted from Hekking (1988), separates the distinctive new *Rinorea* from its Neotropical congeners. Group names are informal names proposed by Hekking (1988).

KEY TO INFORMAL TAXONOMIC GROUPS OF NEOTROPICAL *RINOREA*

- 1a. Leaves opposite Pubiflora group
- 1b. Leaves alternate 2
- 2a. Dorsal connective scales strictly apical
. Apiculata group
- 2b. Dorsal connective scales apical and lateral. 3
- 3a. Corollas subequal to weakly zygomorphic; connective scale apices not bifid; developing ovary not differentiated into an apical "cap" on a differently colored and textured base; neither ovary nor capsule stipitate; capsules 3- to 12-seeded.
. *Rinorea* group
- 3b. Corollas strongly zygomorphic; connective scale apices bifid; developing ovary with apical "cap" different in color and texture from ovary base; ovary base persisting as a stipe in fruit; capsules 1-seeded *Rinorea zygomorpha* H. E. Ballard & Wahlert

Rinorea zygomorpha H. E. Ballard & Wahlert, sp. nov. TYPE: Ecuador. Prov. Napo: Añangu, in the Parque Nacional Yasuní, 0°31'30"S, 76°23'W, 260–350 m, Dec. 1983, *J. Korning & K. Thomsen 8610* (holotype, AAU; isotypes, MO, NY). Figure 2.

Haec species quoad folia alterna, nervationem tertiarium scalariformem et inflorescentiam thyrsoformem ad *Rinoream guianensem* Aublet accedit, sed ab ea corolla zygomorpha, petalo postico dense lanato, filamentorum summo tubi

irregulariter lacerato, antherarum connectivorum dorsalium apicibus bidentatis, ovario maturescenti e pileo apicali indurescente suturis indentatis manifestis notato, fundo ovarii in fructu pro stipite persistenti atque in capsula semine solitario lateraliter compresso et affixo differt.

Tree 3–20 m tall, stem to 20 cm diam.; terminal branchlets terete, glabrous or hispidulous. Leaves alternate, petiolate; petiole 5–13 mm, glabrescent or strigillose; stipules persistent, free, lanceolate, 5–10 × 0.9–2 mm, herbaceous, outer surface glabrous or sparsely strigillose, veins present, margin entire, ciliolate, apex acuminate; leaves elliptic, lanceolate-ovate, or broadly lanceolate, blade 13–20 × 4.5–8.5 cm, herbaceous (occasionally papery or subcoriaceous), adaxially glabrous, abaxially glabrous or strigillose, midrib glabrous or strigillose, leaf domatia absent, secondary veins 9 to 11, ascending, tertiary veins scalariform, base rounded or subtruncate to broadly cuneate, symmetrical, margin crenate or subserrate to subentire, glabrous, apex acuminate or cuspidate. Inflorescences axillary, lateral, terminal or subterminal, pseudoracemose or basally branched thyrses, 5.5–13 cm long, 3–15 cm diam., lateral cymules with 3 to 5 normal flowers and often few to several additional aborted flower buds, axis puberulent; pedicel 1.5–2.7 mm, articulated near the middle, hispidulous; peduncle bracts eventually deciduous, broadly triangular, ca. 2.2 × 1.4 mm, herbaceous, 1-veined, outer surface hispidulous, margin entire, ciliolate, apex abruptly mucronulate; pedicel bractlets deciduous. Flowers 3.7–4.7 mm, bisexual; sepals subequal in size and shape, suborbicular or narrowly ovate, 1.9–2 × 1–1.5 mm, (1)3- to 5-veined, outer surface sparsely hispidulous, margin entire, ciliolate or ciliate, apex obtuse or rounded; petals white or cream, petal aestivation apotact, corollas zygomorphic; posterior ("upper") pair of petals broadly oblong or narrowly elliptic, 3.2–3.7 × 0.8–0.9 mm, outer surface pilosulous or puberulent, inner surface glabrous, margin ciliate near the base, apex rounded; lateral petals weakly bottle-shaped and often somewhat falcate, 3.2–3.8 × 1.2–1.3 mm, outer surface pilosulous or pubescent, inner surface sparsely pilosulous apically, margin ciliate, apex rounded; anterior ("bottom") petal strongly bottle-shaped, 3.6–3.8 × 1.1–1.3 mm, outer surface strigillose along costa, inner surface pilose throughout, margin ciliate, apex deeply emarginate, the lobes often incurled; stamens 5, 3–3.5 mm, all filaments almost fully connate into a continuous tube, tube ca. 0.3 mm tall below anthers, glabrous, irregularly lacerate at summit; anthers borne on very short free portion of filament, free portion attached to inner upper surface of filament tube, ca. 0.1 × 0.1–0.2 mm; anther connectives ovate, 0.7–0.8 × ca. 0.7 mm, outer

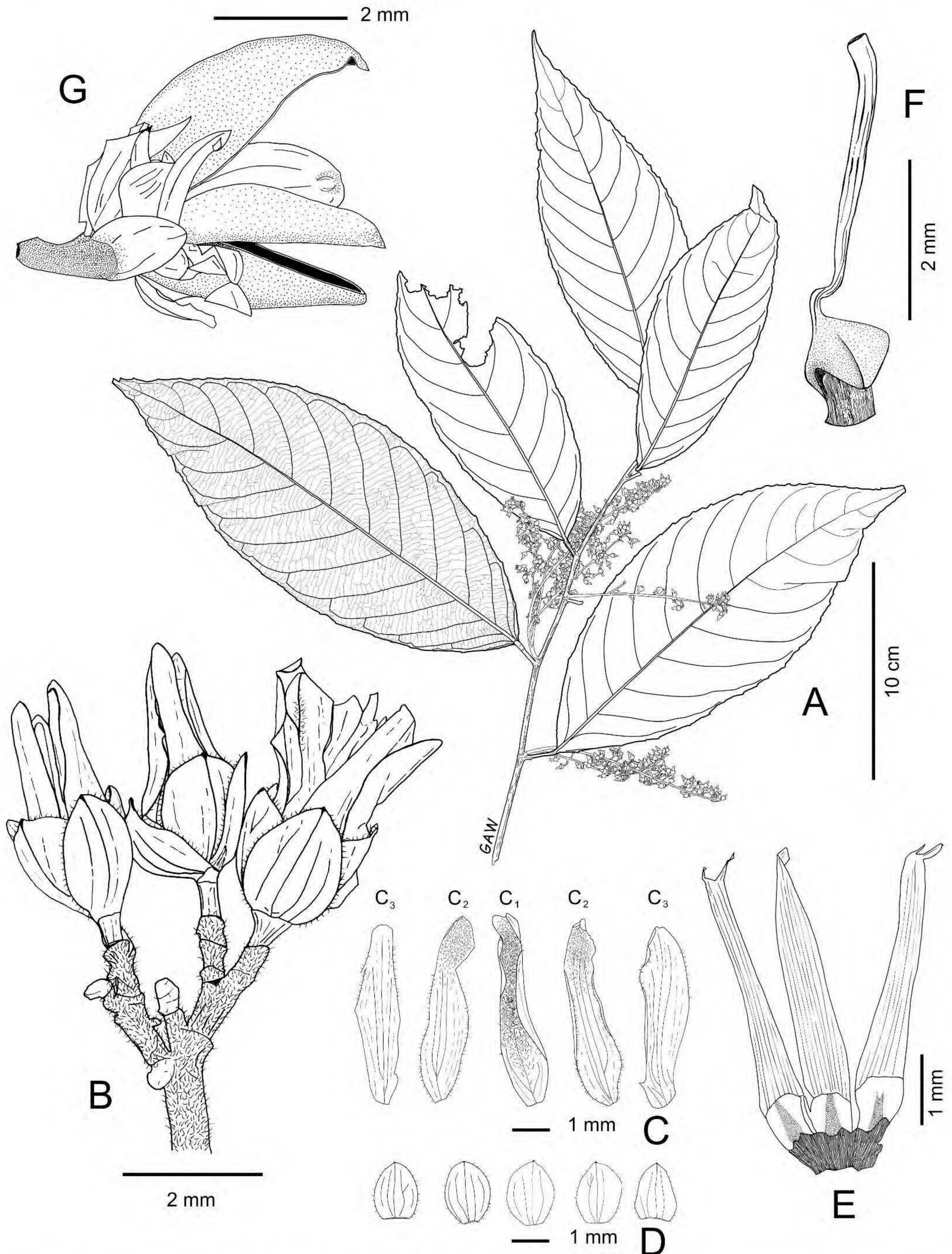


Figure 2. *Rinorea zygomorpha* H. E. Ballard & Wahlert. —A. Habit. —B. Lateral cymule. —C. Petals: C₁, anterior (“bottom”) petal; C₂, lateral petals; C₃, posterior (“upper”) petals. —D. Sepals. —E. Androecium, exterior view showing irregularly lacerate staminal tube, three anthers, and associated dorsal connective scales with bifid apices. —F. Ovary, showing developing apical “cap” and stipe. —G. Fruit, showing unequal valves and seed. A, B drawn from paratype, D. Neill 8532 (MO); C–F drawn from holotype, J. Korning & K. Thomsen 8610 (AAU); G drawn from paratype, T. B. Croat 67467 (WIS).

surface glabrous; dorsal connective scales large and conspicuous, apical as well as lateral, lanceolate-ovate, orange, $2.7\text{--}3.2 \times 0.9\text{--}1.1$ mm, outer surface glabrous, margins entire except for distinctly bifid apex; ovary maturing after fertilization from an apical pale brown “cap” different in color and texture from ovary base; ovary “cap” becoming indurate, with deep and prominent sutures representing dehiscence lines of capsule, apex sparsely hirsute, blackish base persisting as stipe in mature capsule, eventually turning brown and converting to similar texture as rest of fruit, glabrous; style 2.8–3 mm, erect, filiform or subclavate, straight or sigmoid, apically curved, glabrous; stigmatic orifice apical, undifferentiated. Fruit a thick-walled hard capsule, dehiscent along 3 straight sutures, asymmetrically narrowly ovoid, $4.3\text{--}6.5 \times 4.3\text{--}4.6$ mm, strongly zygomorphic with 1 valve much broader than other 2; young fruits green, mature fruits tan to light brown, outer surface smooth, sparsely hirsute or glabrate near apex, apex obtuse; 1 seed per capsule, seed ca. 2.5×1.9 mm, globose in profile, laterally compressed with longitudinal furrow including funiculus, lateral attachment, tan, glabrous.

Distribution and habitat. *Rinorea zygomorpha* occurs in Ecuador and Peru, in lowland humid tropical rainforests, pastures, river terraces, and well-drained hills. It grows on red oxisols or acidic clay soils, from 150–450(800) m elevation. The species has also been collected in Panama and is expected in Colombia.

IUCN Red List category. An explicit conservation assessment following IUCN criteria (IUCN Standards and Petitions Working Group, 2008) was conducted following the general procedure outlined by Willis et al. (2004). This utilized a recently designed extension for ArcView GIS 3.2 software (Environmental Systems Research Institute, 1999) by Moat (2007). After placing the CATS (Conservation Assessment Tools) extension in the main software folder for ArcView, georeferenced records representing all known localities for *Rinorea zygomorpha* were extracted from a BRAHMS (Botanical Research and Herbarium Management System) database (Filer, 2008) of Neotropical Violaceae and mapped to ArcView. The point data were analyzed by the CATS extension in three different ways to ascertain IUCN categories: the first analysis investigated all localities across the entire range of the species; the second and third analyses examined the disjunct Panamanian and South American points separately. The first, total range analysis with 23 records representing 13 distinct localities gave an extent of occurrence (EOO) estimate of 283,891.74 km² and area of occupancy (AOO) estimate of 157,944.53 km², with a recommended

category in each case of Least Concern (LC). The second analysis examining only the two Panama records could only provide an AOO estimate of 177.04 km², which places the Panamanian localities in the Endangered (EN) category. The third analysis focusing on the 21 records representing 11 localities in the species’ main range yielded an EOO of 34,436.58 km² and an AOO of 22,803.13 km², with recommended categories of Near Threatened (NT) and Least Concern (LC), respectively. Because the Panamanian specimens are not presently considered distinct at any taxonomic level from those in the main range, we accept the broader conclusion of Least Concern (LC) as an appropriate IUCN status for the species based purely on geographic range data. Additional corroborative evidence supporting this status includes the protective conditions provided to several populations in Ecuador within reserve boundaries of the Estación Biológica Jatun Sacha and Parque Nacional Yasuní.

Phenology. The species produces flower buds from July through November, mature open flowers from December through February, and mature fruits from September through February. It is possible that at least some of the “flower buds” on plants also bearing mature fruits in September and October are actually cleistogamous, but this requires further investigation to confirm the breeding system.

Etymology. The specific epithet *zygomorpha* refers to the strongly zygomorphic corollas of this species, a character that is unknown in all other Neotropical *Rinorea*.

Relationships. A maximum parsimony analysis of chloroplast *trnL* intron and *trnL-F* spacer sequences from 60 species of *Rinorea* from Latin America, Asia, and Africa shows the new species to occupy a near-basal position in a phylogeny of the genus (results not shown). *Rinorea zygomorpha* is placed in a moderately well-supported clade containing two other alternate-leaved Neotropical taxa: *R. bahiensis* (Moriciand) Kuntze and *R. guianensis* (Wahlert & Ballard, unpublished data). This three-species clade corresponds to Hekking’s (1988) informal infrageneric group *Rinorea*.

Paratypes. ECUADOR. **Morona-Santiago:** Morona, Cordillera de Cutucú, Centro Shuar Uunsuants/TransKutuku, 2°32’S, 77°53’W, 800 m, 20 Jan. 2002, G. Toasa & M. Tirado 8664 (MO). **Napo:** Cantón Tena, Estación Biológica Jatun Sacha, Río Napo, 8 km al E de Misahuallí, Parcela Permanente 03, 1°04’S, 77°36’W, 400 m, 26 Dec. 1989, C. E. Cerón M. & M. Montesdeoca 8138 (MO, U); Estación Biológica Jatun Sacha, 8 km al E de Misahuallí, 1°04’S, 77°36’W, 450 m, 17 Nov. 1988, C. E. Cerón M. & C. Iguago 5623 (BHO, MO, U); Estación Biológica Jatun Sacha, Río Napo, 8 km al E de Misahuallí, 1°04’S, 77°36’W, 450 m, 28

July 1988, *D. Neill* 8532 (MO); Estación Biológica Jatun Sacha, 1°04'S, 77°36'W, 450 m, 24 Aug. 1988, *C. E. Cerón M. & M. Cerón* 4577 (U); Orellana, Yasuní National Park, Maxus petroleum pipeline rd., under construction, Km 18–26, 0°35'S, 76°30'W, 230 m, 11 Dec. 1993, *D. Neill, G. Tipaz & A. Dik* 10276 (U); Canton Tena, Estación Biológica Jatun Sacha, 8 km al E de Misahuallí, Parc. Perm. 03-04-04, 1°4'S, 77°36'W, 400 m, 23 Jan. 1989, *C. E. Cerón M.* 6120 (MO); Cantón Tena, Estación Biológica Jatun Sacha, Río Napo, 8 km al E de Misahuallí, junto al riachuelo Chinguiipino, Parc. Perm. 03, arbol 04.04, 1°4'S, 77°36'W, 400 m, 26 Dec. 1989, *C. E. Cerón M. & M. Montesdeoca* 8180 (MO); colecciones alrededor de reserva florística "El Chunchu," aproximadamente 6 km de Río Payamino, 0°26'S, 77°06'W, 300 m, 15 Dec. 1987, *W. Palacios* 2282 (BHO, MO, U); Orellana, Parque Nacional Yasuní, carretera y oleoducto de Maxus en construcción, Km 46–52, 0°47'S, 76°30'W, 250 m, 1 Sep. 1993, *M. Aulestia & J. Andi* 382 (U); Orellana, Parque Nacional Yasuní, carretera y oleoducto de Maxus en construcción, Km 54–58, 0°48'S, 76°30'W, 250 m, 26 Sep. 1993, *M. Aulestia & N. Andi* 732 (MO); Añangu, in the Parque Nacional Yasuní, 0°31'30"S, 76°23'W, 260–350 m, 24 Oct. 1983, *K. Thomsen & J. Korning* 8618b (AAU); Añangu, in the Parque Nacional Yasuní, 0°31'30"S, 76°23'W, 260–350 m, 14 Mar. 1983, *J. Lawesson, T. Lassø & P. M. Jørgensen* 8618a (AAU); Añangu, in the Parque Nacional Yasuní, 0°31'30"S, 76°23'W, 260–350 m, Dec. 1983, *J. Korning & K. Thomsen* 8610 (AAU); NW corner of the Parque Nacional Yasuní, 0°32'S, 76°22'30"W, 300 m, 1 Oct. 1983, *J. Korning & K. Thomsen* 47195 (AAU); Añangu, in the Parque Nacional Yasuní, 0°31'30"S, 76°23'W, 260–350 m, 1 Dec. 1983, *K. Thomsen & J. Korning* 8618c (AAU); Añangu, NW corner of the Parque Nacional Yasuní, along SEF line in terra firme forest, near Tiputini trail, 0°32'30"S, 76°22'30"W, 300 m, 14 Jan. 1985, *B. Øllgaard, J. Korning & K. Thomsen* 57098 (U). PANAMA. **Coclé:** Penonomé–Coclecito, 5.6 mi. N of Llano Grande, along Río Cascajál, 1.4 mi. N of Continental Divide, 8°46'N, 80°27'W, 150 m, 11 Sep. 1987, *T. B. Croat* 67467 (U, WIS). **Colón:** Santa Rita lumber rd., ca 16 km E of Colón, 9°18'N, 79°47'W, 5 Oct. 1969, *R. L. Dressler & W. H. Lewis* 3734 (MO, U). PERU. **Amazonas:** Bagua Province, Distr. Imaza, Río Cenepa region, region NO del Marion, Comunidad Yamayakat, 4°55'S, 78°19'W [sic], 300 m, Jan. 1995, *V. Hodges & J. Gorham* 64 (MO); Bagua Province,

Yamayakat, Bosque de Rivera, 4°55'S, 78°19'W, 320 m, 4 Feb. 1996, *N. Jaramillo, M. Jaramillo & D. Chamit* 1072 (MO); Bagua Distr., Soldado Oliva, 5°18'S, 78°20'W, 600 m, 6 Feb. 1999, *R. Vasquez, C. Vargas, J. Yactayo & E. Palomino* 26026 (BHO, MO).

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